

Dec. 13, 1966

E. SALZER

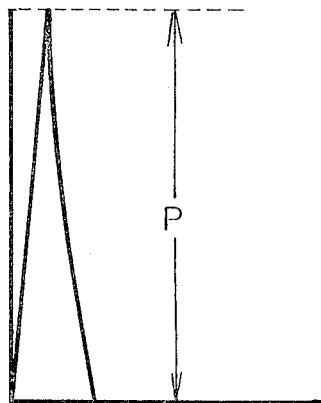
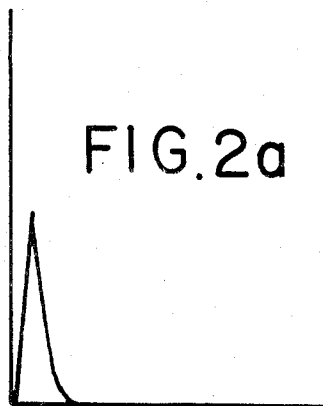
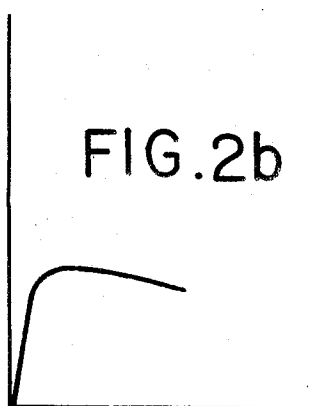
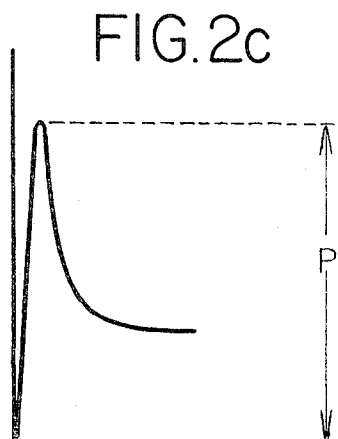
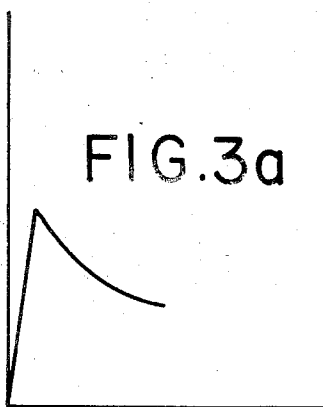
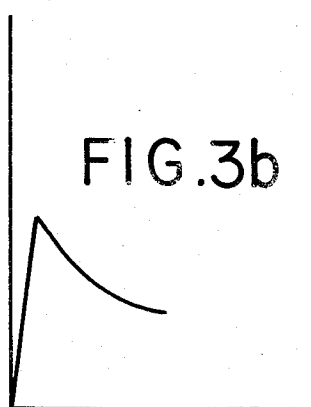
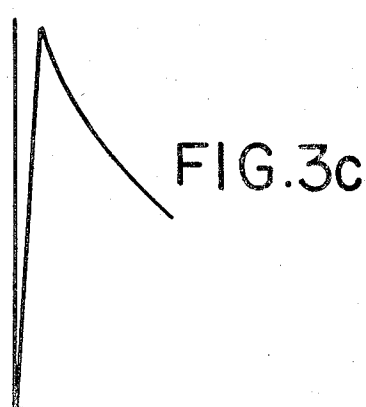
3,291,941

CURRENT-LIMITING FUSE PRECLUDING OVERSHOOT OF THE LET-THROUGH
CURRENT PEAK OVER THE FUSING CURRENT PEAK

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3 Sheets-Sheet 1

FIG. 1



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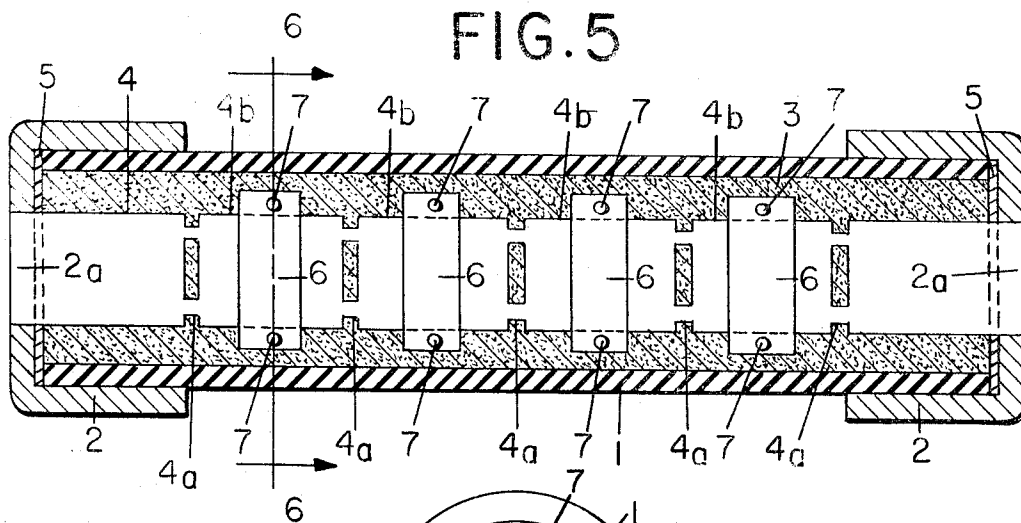


FIG. 6

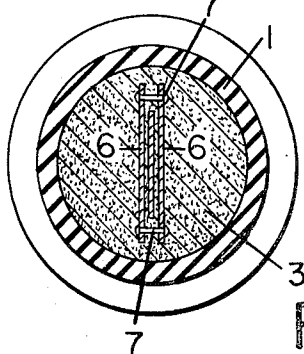
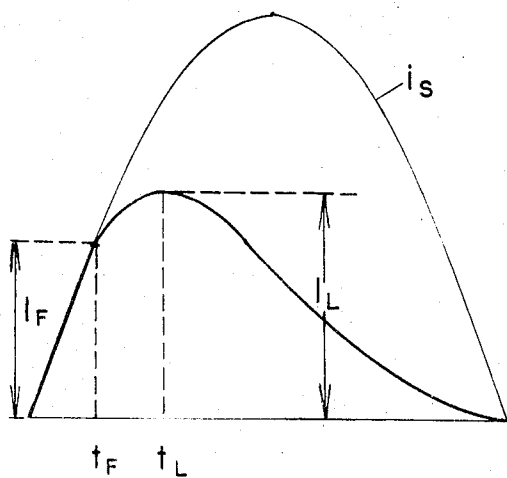
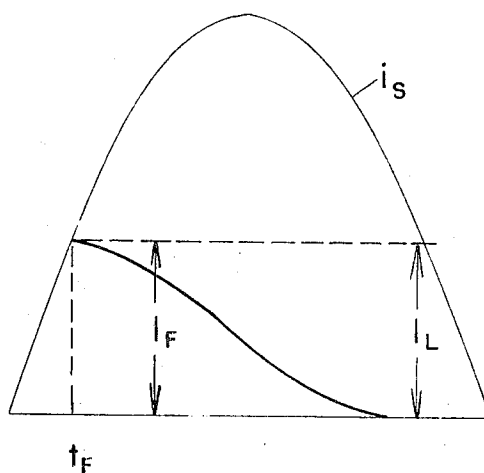


FIG. 4

FIG. 4a



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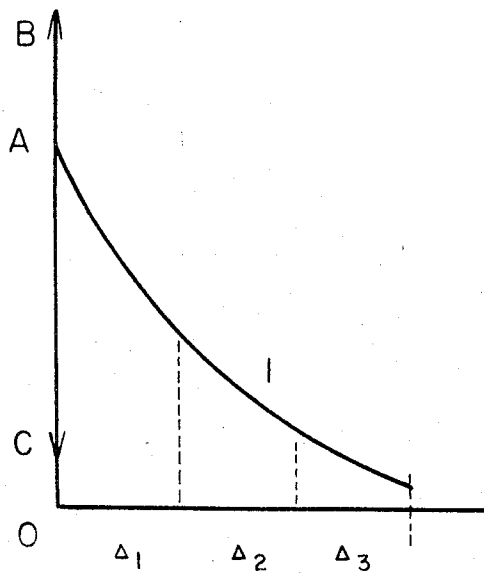
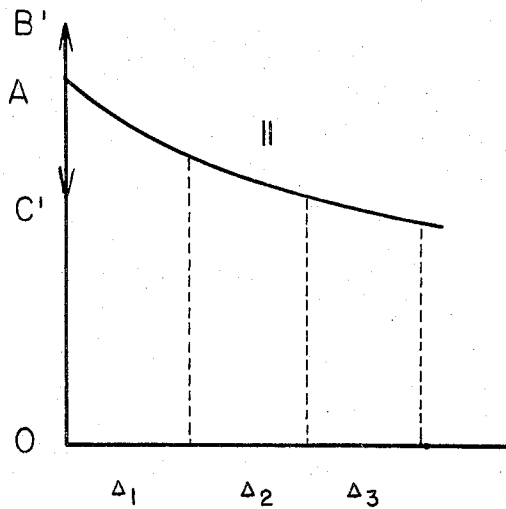
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3,291,941

CURRENT-LIMITING FUSE PRECLUDING OVERSHOOT OF THE LET-THROUGH CURRENT PEAK OVER THE FUSING CURRENT PEAK

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4 Claims. (Cl. 200-120)

This invention relates to current-limiting fuses.

It is one object of this invention to provide current-limiting fuses having a relatively stable arc voltage.

Another object of this invention is to provide current-limiting fuses precluding an overshoot of the let-through current peak over the fusing current peak and, by so doing, minimizing let-through $i^2 \cdot dt$ values.

United States Patent 2,964,604 to P. C. Jacobs et al., Dec. 13, 1960, Current-Limiting Fuses Having Compound Arc-Voltage Generating Means, is concerned with current-limiting fuses conceived for the purpose of achieving a relatively stable arc voltage. The arc voltage of fuses according to the above patent is the sum of two components, i.e. a first component having a high initial rate of rise and decreasing rapidly upon having reached a relatively high peak, and a second component having a relatively low initial rate of rise and decreasing slowly upon having reached a relatively low peak value. The first component of the arc voltage is due to the presence of one or more points of initial break which are exposed to the immediate action of a pulverulent arc-quenching filler, preferably quartz sand. The second component is due to the presence of one or more points of initial break sandwiched between a pair of plates of a synthetic-resin-glass-cloth laminate.

The structure of United States Patent 2,964,604 tends to produce arc voltages whose peaks are less than the peaks which would obtain under identical conditions in otherwise identical fuse structures wherein the aforementioned sandwiching plates of a synthetic-resin-glass-cloth laminate are omitted. Therefore the fuse structures of United States Patent 2,964,604 are particularly desirable where the initial arc voltage tends to be too high, and where it is desirable, or at least permissible, to reduce the initial peak value of the arc voltage by providing the synthetic-resin-glass-cloth sandwiching plates disclosed and claimed in the above United States patent.

There are instances where the highest value of the arc voltage incident to fusion and vaporization of a fuse link tends to be relatively low. In such instances the peak of the let-through current tends to overshoot the peak of the fusing current. This is not objectionable, or permissible, in a number of applications. It is, however, very objectionable, or intolerable, wherever the limitation of let-through $i^2 \cdot dt$ values is critical. In instances where the highest value of the arc voltage tends to be low, and the let-through current overshoots the fusing current, such overshooting is aggravated in the presence of the structure of United States Patent 2,964,604. In other words, that structure should not be applied in such instances. On the other hand, the problem of stabilization of the arc voltage is almost always present, i.e. whether the highest value thereof tends to be relatively low, or relatively high.

It is, therefore, another object of this invention to provide current-limiting fuses having means for stabilizing the arc voltage which are not predicated on any reduction of the peak value of the arc voltage, and preclude the arc voltage from decreasing too rapidly upon having reached its peak value.

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For a better understanding of the invention reference may be had to the accompanying drawings in which:

FIGS. 1, 2a-2c, and 3a-3c are diagrammatic arc voltage traces obtained under various conditions;

FIGS. 4 and 4a are diagrammatic current traces obtained under different conditions;

FIG. 5 is a longitudinal section of a fuse embodying the present invention;

FIG. 6 is a section of the structure of FIG. 5 taken along 6-6 of FIG. 5; and

FIGS. 7 and 7a are schematic diagrams explaining the operation of the structure of FIGS. 5 and 6.

Referring now to the drawings, FIG. 1 shows diagrammatically the arc voltage occurring in a current-limiting fuse plotted against time. FIG. 1 refers to a situation wherein the peak P of the arc voltage tends to be relatively high and the decrease of the arc voltage too rapid.

FIGS. 2a and 2b show the two components of a composite arc voltage resulting from the application of the structure of United States Patent 2,964,604 and FIG. 2c shows the sum of the arc voltages of FIGS. 2a and 2b. It is apparent from a comparison of FIGS. 1 and 2c that the application of the structure of United States Patent 2,964,604 resulted in a reduction of the peak of the arc voltage from P to P' and in a reduction of the rate of decrease of the arc voltage.

In a situation wherein the peak P of the arc voltage of FIG. 1 is about right, but the arc voltage is decaying too rapidly, the arc voltage should be modified as shown in FIG. 3c. This can be achieved, according to the present invention, by making it the sum of the two components shown in FIGS. 3a and 3b, the structure of FIGS. 5 and 6 yielding these two components.

In FIGS. 4 and 4a i_f has been applied to indicate an available symmetric short-circuit and I_F has been applied to indicate the peak of the fusing current of a fusible element or fuse link. The peak of the fusing current is reached at the point of time t_F . Where the initial arc voltage is relatively low, the current continues to rise after the time t_F to a peak I_L which is reached at the time t_L , and then begins to decrease (FIG. 4). If the initial arc voltage is relatively high, the current does not rise beyond the peak I_F of its fusing current, i.e. does not overshoot that peak, but begins to decrease instantly at the time t_F (FIG. 4a). The overshoot condition shown in FIG. 4 may be inherent in a given situation. In such a situation the arc voltage should preferably be increased. Since the structure of United States Patent 2,964,604 tends to reduce rather than to increase the peak of the arc voltage, the application of that structure is not indicated in the situation illustrated in FIG. 4.

Referring now to FIGS. 5 and 6, numeral 1 has been applied to indicate a tubular casing of insulating material closed on the ends thereof by a pair of terminal elements 2 in the form of caps or ferrules. Casing 1 is filled with a pulverulent arc-quenching filler 3, preferably quartz sand. A fusible element 4 in form of a copper ribbon or silver ribbon is arranged inside casing 1 submersed in filler 3 and interconnects conductively the two terminal elements 2. To this end each terminal element 2 is provided with a slot 2a and each end of fusible element 4 projects into said slot in one of terminal elements 2 and is joined to the respective terminal element 2 by a solder joint (not shown). Washers 5 of asbestos or another reasonably heat resistant material are arranged between the axially outer ends of casing 1 and terminal caps 2, and the ends of fusible element 4 project transversely through slots in said washers registering with the aforementioned slots 2a in terminal elements 2. Fusible element 4 defines five serially related points 4a of reduced cross-sectional area, or of relatively small cross-sectional

area. Each of these four points 4a is established by three rectangular perforations arranged along a straight line extending transversely across fusible element 4. Fusible element 4 further defines four serially related points 4b of relatively large cross-sectional area, each arranged between two points 4a of reduced cross-sectional area. The axial extent of the points 4a of reduced cross-sectional area is very limited in comparison to the axial extent of the points 4b of relatively large cross-sectional area. Each point 4a of reduced cross-sectional area forms two point-heat-sources when fusible element 4 is carrying current. The change in cross-section from the points 4a of reduced cross-sectional area to the points 4b of relatively large cross-sectional area is abrupt. The small axial extent of the points 4a of reduced cross-sectional area coupled with the above-mentioned abrupt change in cross-section tend to limit the arc voltage formed at each point of break. Each point of relatively large cross-sectional area is sandwiched between a pair of barrier plates 6 of insulating material, preferably a synthetic-resin-glass-cloth laminate. Among such laminates melamine-glass-cloth laminates are particularly useful for the purpose in hand. Each pair of barrier plates 6 is secured to fusible element 4 by a pair of eyelets 7 projecting transversely through both plates of the pair and avoiding fusible element 4. Each pair of plates 6 is disposed between points 4a of reduced cross-sectional area and none of the pairs of plate 6 covers any point 4a of reduced cross-sectional area. Since all points of reduced cross-sectional area are fully exposed to the quenching action of the pulverulent filler 3, the initial rate of rise of the arc voltage and the peak of the arc voltage are not affected by the presence of plates 6, i.e. initially the arc voltage is of the same magnitude as in the absence of plates 6. The presence of plates 6 decelerates the decrease of the arc voltage after it has reached its peak because of the evolution of relatively cool gases from the plates 6. While it is true that the cooling action of quartz sand 3 upon the portion of the arc path between pairs of plates 6 is less than cooling action in the absence of plates 6 and, therefore, generation of a smaller arc voltage might be expected incident to burnback in the presence of plates 6 than in their absence, their presence imparts to the voltage of the arc burning inside of the gap defined between plates 6 the kind of stability illustrated in FIGS. 3a and 3b. Each of these two figures shows the sum of the arc voltages across one of the two pairs of series breaks of the structure of FIGS. 5 and 6.

FIGS. 7 and 7a illustrate diagrammatically the present situation. In FIGS. 7 and 7a arc voltage is plotted versus time. At the time 0 arc voltage OA is supposed to prevail across an arc gap. Δ_1 , Δ_2 , Δ_3 are successive increments of time. According to FIG. 7 the arc voltage is supposed to increase during the increment of time Δ_1 an amount equal to AB due to backburning in quartz sand and to decrease an amount equal to AC due to protracted heating of the arc gap. Consequently, the arc voltage will be $OA+AB-AC$ at the end of the increment of time Δ_1 , the arc voltage decreasing along curve I. According to FIG. 7a the arc voltage increases during the increment of time Δ_1 from its initial value OA an amount equal to AB' due to evolution of relatively cool gases from plates 6 which flow into the air gap and the arc voltage decreases an amount equal to AC' due to protracted heating of the arc gap region. While $AB > AB'$, the ratio of $AB/AC < AB'/AC'$ and, therefore, the decrease of the arc voltage according to curve II occurs at a smaller rate than the decrease of the arc voltage according to curve I. The arc voltage OA may be considered as resulting from a predetermined degree of backburning in quartz sand, curve I referring to continued backburning in quartz sand and curve II referring to continued backburning between a pair of plates 6 (FIGS. 5 and 6) of a melamine-glass-cloth laminate.

It will be understood that various modifications and

changes may be made in the embodiment of the invention which has been illustrated and described herein without departing from the scope and spirit of the invention as defined by the following claims.

I claim:

1. A current-limiting fuse precluding overshoot of the let-through current peak over the fusing current peak comprising in combination:
 - (a) a tubular casing of insulating material;
 - (b) a pair of terminal elements closing the ends of said casing;
 - (c) a pulverulent arc-quenching filler inside said casing;
 - (d) a fusible element in ribbon-form inside said casing, submersed in said filler and conductively interconnecting said pair of terminal elements, said fusible element defining a plurality of serially related points of reduced cross-sectional area; and
 - (e) sandwich plate means of a gas-evolving insulating material for said fusible element arranged to sandwich only portions of said fusible element situated between said plurality of points of reduced cross-sectional area and to expose all of said plurality of points of reduced cross-sectional area to the immediate action of said arc-quenching filler.
2. A current-limiting fuse precluding overshoot of the let-through current peak over the fusing current peak comprising in combination:
 - (a) a tubular casing of insulating material;
 - (b) a pair of terminal elements closing the ends of said casing;
 - (c) a body of quartz sand filling said casing;
 - (d) a fusible element in ribbon-form inside said casing, submersed in said body of quartz sand and conductively interconnecting said pair of terminal elements, said fusible element defining a plurality of serially related points of reduced cross-sectional area; and
 - (e) a plurality of pairs of sandwich plates of a synthetic-resin-glass-cloth laminate mounted on said fusible element, said plurality of plates being arranged to sandwich only portions of said fusible element situated between said plurality of points of reduced cross-sectional area and to expose all of said plurality of points of reduced cross-sectional area to the immediate action of said body of quartz sand.
3. A current-limiting fuse for precluding an overshoot of the let-through current peak over the fusing current peak comprising in combination:
 - (a) a tubular casing of insulating material;
 - (b) a pair of terminal elements closing the ends of said casing;
 - (c) a pulverulent arc-quenching filler inside said casing;
 - (d) a fusible element in ribbon-form inside said casing, submersed in said filler and conductively interconnecting said pair of terminal elements, said fusible element defining a plurality of serially related points of relatively small cross-sectional area and said fusible element further defining a plurality of serially related points of relatively large cross-sectional area, each of said plurality of points of relatively large cross-sectional area being situated between two of said points of relatively small cross-sectional area; and
 - (e) a plurality of insulating barriers equal in number to said plurality of points of relatively large cross-sectional area, each of said plurality of insulating barriers being mounted on said fusible element at a point thereof intermediate two of said points of relatively small cross-sectional area, said plurality of insulating barriers exposing all of said plurality of points of relatively small cross-sectional area of said fusible element to the immediate action of said arc-quenching filler.

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4. A current-limiting fuse for precluding an overshoot of the let-through current peak over the fusing current peak comprising in combination:

- (a) a tubular casing of insulating material;
- (b) a pair of terminal elements closing the ends of said casing;
- (c) a body of quartz sand filling said casing;
- (d) a fusible element in ribbon-form inside said casing, submersed in said body of quartz sand and conductively interconnecting said pair of terminal elements, said fusible element defining a plurality of serially related points of relatively small cross-sectional area and a plurality of serially related points of relatively large cross-sectional area, the change in cross-sectional area from each of said plurality of points of relatively small cross-sectional area to each of said plurality of points of relatively large cross-sectional area being abrupt; and
- (e) a plurality of pairs of plates of a synthetic-resin-glass-cloth laminate equal in number to said plurality of points of relatively large cross-sectional area, each of said plurality of pairs of plates sandwiching but one of said plurality of points of relatively large

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cross-sectional area of said fusible element and said plurality of pairs of plates exposing all of said plurality of points of relatively small cross-sectional area of said fusible element to the immediate action of said body of quartz sand.

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